FROM SIMULATION TO SURGERY: PERSONALISED BIOMECHANICAL TREATMENT FOR KNEE OA

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Background

Osteoarthritis (OA) is a leading cause of global Years Living with Disability (YLD) with knee OA accounting for 85% of the burden. Over 57m people in Western Europe suffer from OA, this number has grown by 54% since 1990. About 45% of the people that suffer from OA are under the age of 65. Knee replacement is an effective treatment but is only suitable for end-stage disease and generally not recommended for people under the age of 65; this leaves many people suffering with pain and disability for over a decade. High Tibial Osteotomy (HTO) is a demonstrated clinically effective treatment for early knee OA, but its use has declined in part due to increased surgical confidence in knee replacement. HTO surgical technique is challenging and outcomes are dependent upon correction accuracy, and these issues are barriers to the treatment being widely offered by surgeons. A key advantage of HTO is that it can be used at considerably earlier stages of knee OA and is particularly suited to younger people. This talk details the programme of work done to create a new personalised HTO treatment aimed at addressing the barriers of surgical technique and correction accuracy.

Recent Advances

The bipedal nature of human gait results in greater load being applied to the medial compartment of the knee during activity and explains why the majority of knee OA begins in medial compartment. HTO surgery realigns the joint and has been demonstrated to improve frontal plane moment and gait patterns[1], and this reduces estimated loads in the medial compartment[2]. We have created a novel personalised HTO procedure, which simplifies surgery and reduces operative time to less than 30 minutes using 3D printed HTO plates and jigs[3,4]. We have shown that personalised 3D printed plates can safely accommodate variable bridging spans[5] and that personalised devices provide high correction accuracy[6]. The mechanical safety of automatically generated personalised plate geometries was demonstrated by the first fully registered *in silico* trial of an orthopaedic device[7]. The findings were used to gain regulatory approval for the first-in-man trial of this technology[4,8]. A novel method of visualising the locus of the ground reaction vector directly onto the tibial plateau reconstructed from CT data was established[9], this method allows surgeons to directly understand the mechanical consequences of the surgical treatment. The one year clinical results were recently published[8], and show excellent outcomes in terms of function improvement and pain reduction. We are currently running a randomised clinical trial with the aim of comparing personalised to generic HTO treatment in terms of the accuracy of correction, again the results of the *in silico* trial[7] formed part of the submission for regulatory approval. Surgeons are concerned about the influence of HTO surgery on the slope of the tibial plateau, we have been able to show that this can be readily controlled by the placement of primary cut[10].

Richie Gill is currently Professor of Healthcare Engineering at the Department of Mechanical Engineering, University of Bath (2012-). He obtained his DPhil in Biomechanics at the University of Oxford in 1996. He was a post-doctoral fellow at the Nuffield Dept. of Orthopaedic Surgery, University of Oxford 1996-98, Asst. Prof. at University of Calgary 1999-2000 & Lecturer at University of Oxford 2000-12. He is past-President of the British Orthopaedic Research Society. His present research mainly focuses on Orthopaedic Biomechanics. He is an author of 260 publications in peer-reviewed journals, 5 book chapters and more than 450 contributions to International and National Conferences.

Future directions

The current focus is on personalised optimisation of the fixation plate parameters to promote faster bone healing. An open question remains about the required degree of correction, there is increasing evidence that cartilage can have some recovery after HTO. Understanding the post-surgical mechanical factors which promote cartilage healing is important in terms of the surgical planning, and this will form a major strand of future work. It remains important to further lower surgical barriers to ensure this treatment can be made widely available.

References

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